Cyber Security Education and Training
Delivering industry relevant education and skills via Degree Apprenticeships

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Abstract

The rise of Digital Transformation, global pandemics, and AI, have made Cyber skills crucial in today's world. Organisation flexibility can only be achieved when they have a strong foundation of Cyber professionals that can look after vulnerabilities and protect their systems. A multitude of evidence suggests that the economy is being held back due to a skills gap, particularly in the Cyber Security discipline. In seeking to reduce this gap, the UK government has extended a long established 'apprenticeship' programme to include degrees. Higher Education Degree Apprenticeships offer a cost-effective route for employers to upskill their staff and for apprentices to access free education (and a degree) whilst being paid. Each of the Degree Apprenticeships has an associated framework that defines core learning requirements – devised and created by a collaborative effort of industry and academia. How this framework is implemented however is very much up to individual institutions.

This paper presents an implementation of the Cyber Security Analyst degree apprenticeship undertaken at a UK Institution. Amongst the first in the UK to operationalise the standard, the approach has pragmatically dealt with a wide range of issues to create an academically rigorous yet commercially viable solution for industry. The paper presents the approach, demonstrates the academic rigor through mapping to industry-accepted standards, and discusses the collaborative role of the employer and University in providing a holistic and complete learning experience. The paper concludes by offering a critical discussion on challenges and opportunities and suggests ways employers and professional bodies can collaborate further with Higher Education in developing Degree Apprenticeships that will only be about skills, but also lifelong learning.

1.0 Introduction

The Cybersecurity industry is growing and developing fast. Companies, government and educational establishments have been looking into those rapid changes and to promote partnerships amongst those different stakeholders. It is calculated that 48% of the businesses have a skills gap (Pedley et al, 2020) and two thirds face issues with the cyber skills gap. Over the years there has been a plethora of qualifications and certifications in the discipline. There is a growing demand across countries and governments to identify further institutional deficiencies and how to close the skills gap. The Digital Revolution and the continuous economic restructure in Europe, US and all over the world, develops new areas and skills needed and at the same time creates skills shortage. The Skills Mismatch Index (SMI) indicated that the Eurozone alone by 2020 would experience 900,000 shortage of professionals in STEM (Francis and Ginsberg, 2016). The new research paper published in 2019, evidences that these figures are set to get worse and reveals that it could be 7 million under-skilled or their job

requirements (Industrial Strategy Council, 2019). In an attempt to address the current and forecasted skills shortage, the UK government developed the Higher Degree Apprenticeships and UK Higher Education Institutions are now introducing and offering new Bachelors degrees under this new umbrella.

The Cyber Security discipline is a relatively new profession and often organisations are not in a position to identify or recruit the specific skills they need. Although a Computer Science degree can be seen as the foundation of all IT specialisations, still within the Cyber field we need to carefully select such professionals that will bring the expertise and knowledge in the times we live.

Academia has a long-standing background on research outputs and in particular, very recently in Cyber. By developing the Cyber Degree Apprenticeship, HE institutions achieve a great milestone in bridging the gaps between research and organisational needs. In addition, employers can benefit greatly by broadening their recruitment practices and develop new upskilling and transitioning routes for their employees. Evans and Reeder (2010) identified early on that cybersecurity skills are in short supply and it can have implications on terrorism, financial crime, business insider threats and the intelligence community in general. And despite the fact this might seem like a ten-year-old and out date reference, unfortunately it is still very true and this is a long standing issue. More recent studies by Francis and Ginsberg (2016) and the UK Department for Digital, Culture and Media & Sport (2020), make a cyber skills embedded across all the workforce. Globalisation not only on the job market, but also on fields such as education, gaming etc makes it a high priority that more people get upskilled and understand the importance of cybersecurity (European Commission, 2017).

The paper considers the potential of Degree Apprenticeships as a route towards supporting the need for cyber security skills. The discussion begins by presenting the pedagogical considerations that were applied whilst developing the new Degree Apprenticeships and the importance of not only embedding the skills framework, but also to initiate brand new discussions with the employers. It continues by discussing the challenges that all stakeholders faced during the implementation of such degrees, and concludes with lessons learnt and some pedagogical recommendations for a second iteration or for institutions who wish to build upon this experience.

2.0 The development of Degree Apprenticeships and the Skills Framework

The patterns of academic study in the UK is continuously being explored by the government. The (NMC, 2016) report offered a five-year horizon for Higher Education Institutions. The main areas the research was focused on was the use of technology but also how to improve teaching and learning and offering more opportunities within Higher Education. In particular, their research focused extensively in developing competing educational models in an attempt to assist institutions to move away from traditional courses. Having said that, the research acknowledges that such approaches could have implications on policy, leadership and practice.

Similarly, for years there has been a strong incentive to address the relationship between Higher Education and employment. In this rapidly changing world, Higher Education is called to become more responsive and enhance knowledge and skills whilst empowering the critical reflective learner. This has been widely supported by the government by producing various reports discussing the future of Higher Education such as the 2003 UK Government report, the 2008 HEFCE report, the 2011 Government White Paper (Vasileiou, 2018) and the 2015 Advance HE Framework on enabling employability.

From the academic perspective, Higher Education institutions have made employability one of the key aspects of organisational commitment and vision. In traditional degrees, short work-based learning

modules are offered where students are experiencing doing an academic piece of work alongside an employer (GOV.UK, 2017). In addition, students go for a year long optional placement at the end of Year 2 before they enter their final year of their degree.

In addition, during the development of the degrees, the Advance HE framework was adopted on embedding employability (see Figure 1) that can be tailored depending on the type of the degree and desirable outcomes. The host institution's familiarity with employability being a key driver in developing curriculum meant that there was significant prior experience in developing various degree models, including Fast track Degrees (Vasileiou, 2018), prior to the development of the Degree Apprenticeships.

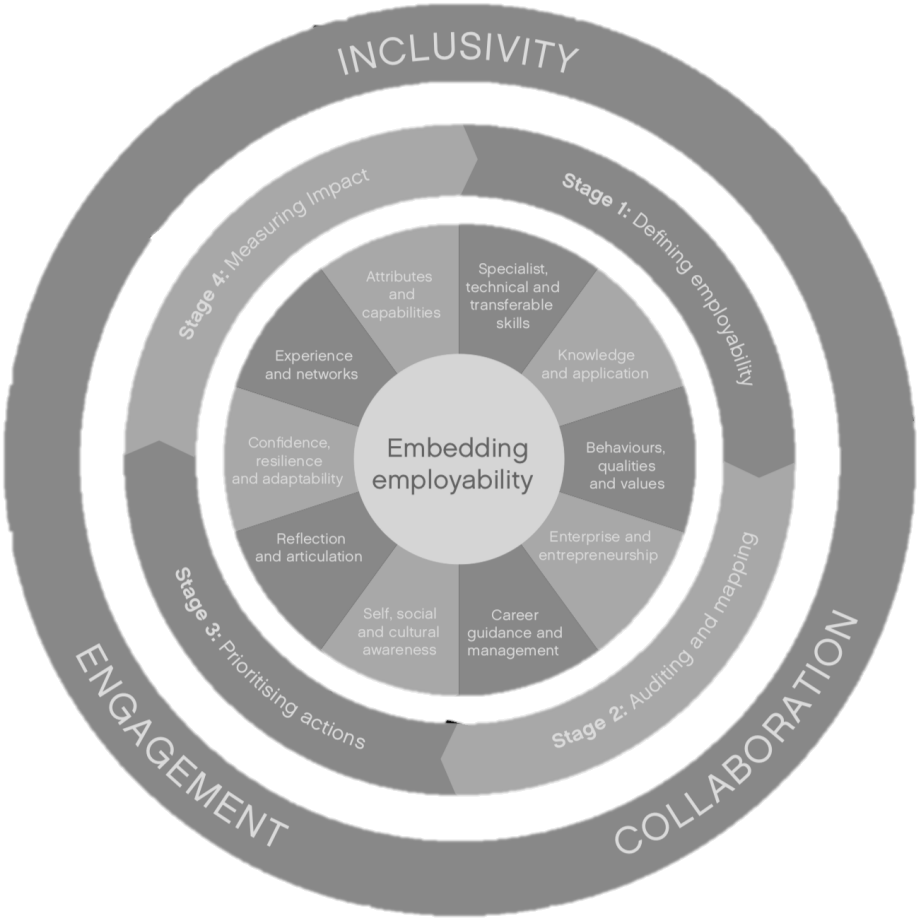

Figure 1. The Framework for embedding employability in HE (Advance HE 2015)

In order to develop the Degree Apprenticeship programmes four distinctive steps were followed:

1. Worked collaboratively with local 10 employers and the UK South West trailblazers group to define employability and skills needed to be addressed. Various meetings were held to discuss the triangulation between the apprenticeship standards, the skills framework and the academic expectations of the learners. Employers provided an in-depth description of the jobs and this facilitated discussions and eventually agreements of the various skills that will be addressed within the academic curriculum.
2. Considered all current policies and future institutional practices and processes and aligned the development of Degree Apprenticeships to the overall strategic vision.

3. Collaborated and shared good practices with employers who have a long-standing experience on running apprenticeships.
4. Continuously collected and assessed feedback from all stakeholders in order to inform future policies and areas of focus.

The final suite of degrees was packaged into the Digital and Technology Solutions programmes Institute for Apprenticeships and Technical Education). This included Cyber Security Analyst, IT Consultant, Network Engineer and Software Engineer. All pathways had distinctive characteristics, but they all had some common modules to develop the foundations of the Computer Science field. The modules were chosen and designed carefully in collaboration with the employers in order to ensure that the Apprenticeship standard were aligned with the modules' content.

3.0 The Cyber Analyst Curriculum and the Professional Skills

The majority of UK Universities ensure their degrees are accredited against professional bodies. Within the Computer Science discipline and its related fields such as Cyber, it is highly important that curriculum updates regularly in order to develop employable graduates. Professional bodies such as BCS (The Chartered Institute of IT) play a key role in developing courses not only meeting the Higher Education quality assurance standards, but also to develop a relationship between HE and understand the skills-based approach. However, this can also create new problems, where professional bodies do not understand the HE context and awards and accreditations becomes a competitive behaviour rather than an informative on developing teaching excellence.

The development of the Degree Apprenticeships programmes relies heavily on the skills set needed by graduates as it was defined by the Government's analysis on the skills gap and the standards published. Such degrees combined learning with employment and the final certificate is not only a degree on understanding the discipline, but also verifies the skills set an individual has acquired. Each apprenticeship standard is a combination of a job, skills needed and the learning that needs to be undertaken. One cannot exist without the other. Traditional courses offered by the HE Institution, were already mapping their learning and skills to the professional standards with great emphasis on the SFIA framework (2018) and the CIISec Skills Framework (CIISec, 2019). The professional bodies work closely with the government and inform the trailblazers and developers of the apprenticeship standards, so in that respect the development of the Cyber degrees was already very well received by students and employers. Whilst developing the academic element, a new mapping exercise was needed where an in-depth analysis of the skills acquired was needed.

Figure 2 shows the Degree Apprenticeship delivery model and how it spreads and embeds the work experience component throughout the years of study. This enables the graduates to be considered as more experienced than those from traditional degrees – even with an optional placement. This aspect was recognised by the professional body (CIISec) which was willing to grant Associate Member status to all Cyber Degree Apprenticeship graduates directly upon graduation (University Business, 2018), whereas traditional degree graduates are not eligible for this level without further practical experience beyond their graduation.

	Year 1	Year 2	Year 3	Year 4
Traditional Bachelor's Degree	120 credits	120 credits	Work Experience (Optional Industry Placement)	120 credits

Degree Apprenticeship	120 credits 20% of the job	120 credits 20% of the job	120 credits 20% of the job
	Work Experience (normal day job)		

Figure 2 : A comparison of the Traditional BSc with the Degree Apprenticeship BSc

It was clear that upon completion of the first two years of the Cyber Degree Apprenticeship, that the discussions held from the outset with employers, students and the University, the development was seen holistically and not just as an academic programme, or just a work experience. The importance embedding the academic element to the daily job - knowledge element of the apprenticeship – created clear links between the practical element of the degree and the theoretical learning. From the beginning of the apprenticeship, both the students and the employers were given clear understanding of expectations in promoting an effective learning environment. Whilst the author had similar experience with all Degree Apprenticeships pathways, extra focus and attention was placed on the Cyber pathway as it is one of the fields rapidly developing and the need to embed professional bodies' frameworks was of high importance. Such an approach enhanced the learner's effectiveness and experience and ensured that Degree Apprenticeships were developed with a holistic pedagogical approach encouraging both employers and learners to engage and meet the academic requirements. This in turn had as a result more employers to showed interest in joining the scheme, and improved attainment and retention.

4.0 Challenges and Opportunities

The professions have been widely challenged to look beyond standard routes into education. Universities have been developing work-based learning approaches (Advance HE, 2015) for a number of years now, so they are not new in understanding the need to build a curriculum embedding professional standards. There are professions such as Healthcare, where the apprenticeship approach is the norm. However, when looking into the Cyber profession the picture is not the same. The emergence of such degrees offered professions a framework to develop partnerships whereas in the past professional bodies would not engage directly. The 'knowledge' and 'competence' frameworks are the beginning to foster practice-based academic qualifications(Lester, S., Bravenboer, D. and Webb, N.,2016). Learning becomes negotiable though, and often the professional body might focus too much on a particular skill, rather than the holistic approach to learning. During the development of the degrees, difficult discussions took place with all parties involved but it also developed the understanding of academic learning further for everyone involved. Academic learning and professional competence whilst different (Anderson, A; Bravenboer, D; Hemsworth, D., 2012)., they became the new integrated way into and out of Higher Education. The professional bodies and their standards whilst focusing on the skills, they were now mapped against critical thinking, evaluation and reflection. Professional values within an HE degree transformed and many barriers were removed.

Transdisciplinary skills reflect in academic work the generic competence a graduate needs and integration of both academic and professional standards become the core.

Patterns and processes are changing in Higher Education. With the introduction of higher fees the landscape was changing already. There has always been discussions and comparisons between apprenticeships, degrees and certifications. Students have been making those hard decisions since their early adult lives. We have seen that quite often students although competent, are not able to attend university. To date, the Higher Apprenticeships have not been offering this holistic approach to learning that Degree Apprenticeships do (Beech and Bekhradnia, 2018). But despite the opportunities that arise, still the young population is struggling to either find employment that will lead them to an apprenticeship or their employer are not investing into their holistic and lifelong education. Therefore, it is of high need that when developing the Degree Apprenticeships they are not being sold as a financial investment for the employer, but in collaboration with the Government and the professional bodies, to inspire and develop the new generation (NCSC , 2019).

Training and teaching learners at the same time, quite often can be problematic. By integrating a variety of pedagogical approaches, moving away from the traditional didactic approach, can enhance and empower the learner and the process in achieving a degree. Understanding just the regulatory framework often is not enough. The author spent adequate time exploring collaborations and opportunities to promote flexible learning in an attempt to promote equal opportunities and cater for diverse backgrounds. This was very well received by the employers and the student feedback was very positive. The Cyber programme was developed with careful consideration of looking into the future and how the discipline expands. Looking the now only would not be enough and upon the creation of new skills by the professional bodies it would be not achievable to reach positive results or it would lead in delays revamping the curriculum. The holistic approach benefited the employers too as they became more compliant with the skills frameworks and developed deeper understanding of the field.

5.0 Recommendations for Stakeholders

The table below summarises some suggestions and recommendations for each stakeholder involved in either developing or taking up a Degree Apprenticeship that derived from the current portfolios of Apprenticeships to date. In particular, the focus is placed on the Cyber pathway as it requires continuous adaptation of skills and new ones develop very quickly due to the nature of the discipline. What is noticeable is that the main recommendation is around collaboration and continuous development of the curriculum alongside the employers. Although apprenticeships have been running for a long time now, Degree Apprenticeships are moving away from just vocational study (Chapman, 2018) and incorporate the academic element more strongly. From an employer's perspective, to employ staff who gain both practical experience and academic one, can prove a great advantage. What is important though is to develop those foundations on working with academia to gain the most out of the theoretical work. The table shows how each stakeholder needs to respond for the main themes when creating a Degree apprenticeship curriculum.

Issue	Universities	Employers	Apprentice
Strategic	Develop an overall strategic approach to implementing Degree Apprenticeships for the Institution.	Develop Degree Apprenticeships as the overall CPD strategy within the organisation.	Develop strategies for self-managing work and education.

Collaborative Approach	Employers should play a key part from very early on.	Work collaboratively with Higher Education Institutions to develop a degree that meets the organisation's needs.	Develop strong collaborations with mentors, line managers and academics.
Triangulation	To empower the relationship between academics and employers and identify each ones' expertise.	Have a clear idea of skills shortage.	Work continuously on their personal CPD, identify their own skills gap
Continuing Professional Development (CPD)	To re-consider and perhaps re-define/re-design the delivery approaches in an attempt that are relevant for both employers and students.	Support the staff to undertake various CPD activities and where appropriate the Degree Apprenticeship route.	
Outreach	Outreach activities to promote Degree Apprenticeships to schools and colleges.	Welcome new talent and support them by offering Degree Apprenticeships.	
Professional Skills	Integrate Professional Skills within the apprentices' academic learning.	Integrate Professional Skills within the apprentices' experiences and embed it in their academic learning.	

Table 2. Steps in developing a Cyber Degree Curriculum

Looking ahead, the above table can be used by each stakeholder involved in developing such schemes. Employers can introduce organisation wide strategies on how to identify the skills gap and either existing employers to upskill or recruit new talent. The above table can facilitate those discussions between all parties and to assist them in designing strategies to increase participation on Degree Apprenticeship schemes.

6.0 Conclusion

The paper critically reflected on the development of the Cyber Degree Apprenticeships within a Higher Education Institution with the aim to demonstrate a new route into developing Cyber professionals. It was highlighted that such route can be valuable to employers and although the author implemented various pathways and special focus is being placed at the Cyber one. As more and more employers identify their organisations' skills gap in the Cyber field, the professional bodies such as CIISec and NCSC (2019) are accepting, promoting and recognising the Degree Apprenticeship route. This led to a rapid grow across many institutions and the Cyber pathways have become very popular. Companies such as HP and IBM, are either upskilling existing staff in this area, or investing in new talent.

Although it is felt that the strategic approach has now resulted in steady student recruitment, at the same time it was a steep learning curve for academia to enter the world of apprenticeships. What was found to be the most important factor affecting a quick growth in student numbers was aligning the development of apprenticeships with an institutional strategy, mission and values. Engaging with the employers from the start, whilst developing the curriculum is also quite important. Questioning and

continuously developing a personalised degree and career development is not something that currently fits widely with the universities (Rowe al, 2017). Teaching and learning strategies and approaches were put on the test often, and new ways of delivering the content emerged and it is still under review. Staff workloads has also been a challenge. Although there is a high need and will from all sides to deliver the same degree but in different formats to meet the employers' needs, equally it has been a great challenge to identify not only suitable staff, but also staff with capacity.

Other areas that still need to be explored are widening participation and inclusivity. HE education provides a provision for all types of learners, giving everyone an opportunity to develop as a person, as a graduate and contribute to the society. Although such educational models can inspire and remove barriers for students who are unable to get a student loan, still HE can influence less and less the student population and intakes. Employers will be providing their workforce and by embedding professional standards into the curriculum, the widening participation aspect is outsourced to all those stakeholders.

In conclusion, despite the new challenges and the changing landscape of mass Higher Education, professional bodies have, employers and the government are called to redefine what degree education means. Whilst universities are still developing and establishing a variety of Degree Apprenticeships, reflection is required on the role of employers and professional bodies (Husband, S., 2018). The latter two, should be supporting the Higher Education establishments in developing and adapting their material (Lester et al, 2016), but not changing the nature of what HE represents and what it aims for. Currently, the implementation of such degrees does not hold the employer or the professional body responsible. With the triangulated approach the Degree Apprenticeships described in this paper followed, it recommends that here needs to be an accountability system where it will require all parties to be clear on their roles in delivering such degrees. It is important that the Government, the employers and the professional bodies, at times they need to adapt to the HE context and change their approaches and how they develop their frameworks (Mikkonen et al, 2017). If this is achieved, then the policy contexts can change, become more inclusive and align university qualifications with businesses.

The Cyber skills gap is not closing (Gov.uk, 2020). On the contrary, with the rapid online developments any degree or pathway in the Computer Science discipline will need elements of embedding skills and knowledge around security and privacy. The Cyber field can be further supported by the Degree Apprenticeships route as the learners have an ongoing exposure to the real problems and challenges of their daily job, in addition to learning the theoretical aspects. Employers are offering most of the times cutting edge technologies and as such this is offering academia the opportunity to stay current and offer the latest theoretical frameworks. Now more than ever, the need of professional bodies is high. They are the ones collecting, collating and framing the profession, offering ongoing support and guidance. Now more than ever, embedding those frameworks within the rapidly changing and growing Cyber field, can be not just a challenge for academia, but also an opportunity to reshape their offerings and produce such graduates that will come with professional and academic experience. Finally, the Degree Apprenticeships route into Cyber, alongside the embedded skills frameworks, will develop such graduates with lifelong learning characteristics which, in return, will be an asset for any organisation and the Cyber profession.

The topic of Degree Apprenticeships is still under development and both government and academia are exploring the next steps. Employers have been evaluating the effectiveness of it and of course given the sudden impact of Covid-19, it has become an interesting point of discussion. Whereas before it was mandatory there was some face to face delivery, it is now impossible due to the global pandemic. In addition, the financial difficulties it has caused to the businesses, has caused concerns of the future of Degree Apprenticeships. Nevertheless, the skills gap in Cyber is growing, and the

pandemic has exposed systems even more. The author is developing a strategic approach to teaching and learning of the Degree Apprenticeships during the pandemic and this will influence the next study and outputs.

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